Vol. LI August, 1926 No. 2

BIOLOGICAL BULLETIN

OBSERVATIONS ON MOTILITY IN CERTAIN CYANOPHYCEÆ.[1]

EDWARD S. CASTLE.

The power of spontaneous movement in the blue-green algæ has been stated by many authors to be confined to the family Oscillatoriaceæ, occurring characteristically in the vegetative filaments of *Oscillatoria*, *Phormidium*, *Spirulina* and *Arthrospira*, and occasionally in the hormogonia of related genera and even of such Heterocysteæ as *Nostoc*, *Scytonema*, and *Rivularia*. In addition, DeBary (1863) and Phillips (1904) have described motion in vegetative filaments of the genus *Cylindrospermum*, a member of the Nostocaceæ.

Recently, however, two species of *Anabæna* occurring on the estate of Mr. E. F. Atkins at Soledad, Cuba, and studied by the writer in the Harvard Laboratory there, were found, although belonging to the Nostocaceæ, to show consistent motility like that characteristic of the Oscillatoriaceæ. These two species were both commonly collected, forming thin scums on damp earth in roadside ditches. In culture bottles they spread rapidly up the sides of the glass in a manner resembling an active *Oscillatoria*, finally covering the whole inside surface with filaments packed side by side in a single layer. Although exhibiting an active motility like that regarded as characteristic of members of the Oscillatoriaceæ, the filaments of both these species were torulose and consistently contained heterocysts that conclusively excluded them from that family. The larger of the two forms (Fig. 1*b*) regularly produced spores and in all essential characteristics justified being identified as a species of *Anabæna;* the other, smaller form (Fig. 1*a*), although it never developed spores during

[1] Studies from the Biological Laboratory in Cuba (Atkins Foundation) of the Harvard Institute for Tropical Biology and Medicine, No. 1.

the two months it was under observation, nevertheless was judged an *Anabæna* on its general morphology. Exact determination of the species was not attempted by the writer but will be referred later to specialists in the classification of the group.

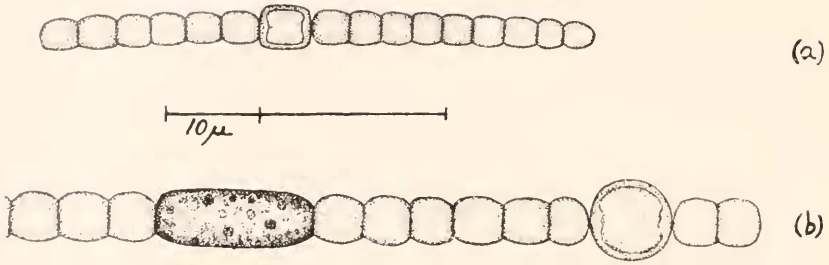

FIG. 1. Portions of the trichomes of the motile species of *Anabæna* studied at Soledad. (*a*) The smaller species showing its characteristic structure. (*b*) The larger species showing the cells, heterocyst, and spore in their characteristic arrangement.

Both these species of *Anabæna* were consistently and actively motile, the motility resembling in general that customary in the Oscillatoriaceæ. Flexion of the whole filament as well as translatory movement was seen in both species, but rotation was not observed. Filaments with heterocysts moved as actively as those without, contrary to what Borzi (1886) observed in the case of species of *Nostoc*. Speed of translation was, within limits, independent of the length of the filament, confirming the observations of Crozier and Federighi (1924) on *Oscillatoria*. At 28.9° C. (84° F.), the rates of translation of these species of *Anabæna*, compared with the rates of some rapidly-motile species of *Oscillatoria*, were:

Anabæna sp.	av. 2.5 μ per sec.
Oscillatoria formosa	" 4.2 μ " "
Oscillatoria princeps	" 5.0 μ " "

The rate of movement in *Anabæna* is thus seen to be half that of *Oscillatoria princeps* and somewhat more than half that of *Oscillatoria formosa* under the same conditions. Although motility has not been reported in *Anabæna* hitherto, the motility which has been recorded frequently in the hormogonia or such related Heterocysteæ as *Nostoc*, *Scytonema*, or *Rivularia* has in-

variably been described as of a very slow nature. The rates given by West (1916, p. 23), as found by Brand for the hormogonia of species of *Phormidium*, vary from 0.004 to 0.058 μ per second, and are thus many times slower than those seen by the writer in the vegetative filaments of *Anabæna;* but it should be noted that the temperature at which these slower rates occurred was not given.

In view of the fact that during the movement of these species of *Anabæna* no rotation was ever observed by the writer, it seemed advisable for comparison to examine species of *Oscillatoria* in this respect, especially since Crozier and Federighi (*loc. cit.*) have expressed some doubt whether rotation of the filaments of *Oscillatoria* does indeed always take place during translation. Careful examination of a considerable number of favorable species of *Oscillatoria* at Soledad has convinced the writer most conclusively that many species do exhibit rotation of the filament around the long axis. In species in which the ends of the filaments were characteristically hooked, this hook, which maintained its peculiar shape, could be seen to rotate through the water in a manner precluding a mere circular bending of the tip. Moreover, in larger species, rotation could be observed very convincingly by following the change in relative position of granules lying at different depths within the cell content.

Also, in view of the fact that West (1916 and 1904), when discussing the motility of *Arthrospira*, states that rotation has not been observed in this genus, it may be of interest to record that in a species studied at Soledad, rotation was found to accompany progression, as in *Spirulina*, while flexion also was seen to occur at times.

Summary.

Two species of *Anabæna*, of the family Nostocaceæ, studied in Cuba, were found to exhibit motion similar to that of the Oscillatoriaceæ. The rate of movement was independent of the presence of heterocysts or of the length of the filament, and was about one half that of actively motile Oscillatoriæ under the same conditions, but much more rapid than that previously recorded for the hormogonia of *Phormidium*. No rotation was observed in these species of *Anabæna* but several species of

Oscillatoria and one species of *Arthrospira* were seen to rotate customarily during free-swimming translation when observed under similar conditions.

REFERENCES.

Borzi.

'86 Le Communicazioni intracellulari delle Nostochinee. Malpighia, 1. (Reviewed in Bot. Cent., 37, 1887.)

Crozier, W. J., and Federighi, H.

'24 Critical Thermal Increment for the Movement of Oscillatoria. Journ. Gen. Physiol., 7, 137–150.

De Bary, A.

'63 Beitrag zur Kentniss der Nostocaceæ insbesonderbare der Rivularien. Flora.

Phillips, O. P.

'04 A Comparative Study of the Cytology and Movements of the Cyanophyceæ. Contrib. Bot. Lab. Univ. of Penna., Vol. II., No. 3.

West, G. S.

'04 British Freshwater Algæ.

'16 Cambridge Botanical Handbooks, Vol. 1, Algæ.